Surprenant Mfg. Co.
Clinton, Mass.

405558

ABSTRACT

The report herein outlined contains technical and factual data concerning physical development and testing procedures and data of three watertight coaxial cables per specification Ships-C-407. This report is the third in a series of four quarterly engineering reports to be submitted to BuShips and various government agencies concerned. This report covers the progress during the period of January 15, 1963 through April 25, 1963. Outlined is the expected progress through the termination of the contract. Explained are testing procedures and equipment used during this quarter as well as all data obtained. Identified are all personnel assigned to this project to date, their functions and connections in regard to the project. Discussed are the purposes of the research and development and results obtained and results expected which are pertinent to the applicable specification MIL-C-4017. Technical procedures and all materials used to gain satisfactory end results are explained as to the reasons for their success or failure, the underlying causes, and corrective actions taken to rectify the various results.

PART I

PURPOSE

1. Fabrication of Center Conductor.

The center conductor of all cables must be fabricated with the following points in mind:

a. Whether a stranded or a solid conductor be used it must be capable of withstanding 1000 PSI hydrostatic pressure applied to the open end of the completed cable without leakage or axial slippage along the cable.

b. Construction must be as pliable as possible over the specified temperature range and still maintain excellent hydrostatic and electrical properties after repeated flexing at these specified temperature.

c. Use of materials in construction with the above qualities and still afford low electrical losses to the completed product.

With these points in mind we fabricated the RG 217/U cable with both solid and stranded and blocked center conductors. The results of tests on both constructions is explained in the Detail Factual Data Section of this report.

2. Primary Dielectric.

The material used in this operation must have the properties to enable it to pass all physical and electrical tests pertinent to specification MIL-C-4017. This includes hydrostatic integrity, low electrical loss properties, good cold bend qualities, resistance to crush under extreme pressure. It must also be as light in weight and small in physical size as possible commensurate with all tests.

3. Application of Outer Conductor.

The outer conductor shall be comprised of either a single or double metallic braid suitably sealed with an appropriate material to withstand the hydrostatic and low temperature bend tests without physical damage to the cable. The outer conductor shall be applied and sealed in such a manner that the lowest possible electrical losses occur.

4. Overall Outer Jacket.

The material used in this operation must be such that it is readily bondable to polyurethane. It must be applied in such a manner that a tight bond occurs between it and the immediate underlying outer perimeter of the cable core. All materials and techniques must be such that all tests called out in specification MIL-C-4017 can be complied with.

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GENERAL FACTUAL DATA

(A) Identification of Personnel

1. Donald C. Alexander - Vice President-Engineering

   Man hours work performed January 15, 1963 to April 25, 1963

2. Richard McKinstry - Project Engineer

   Man hours work performed January 15, 1963 to April 25, 1963

3. E. W. Bennett - Chemical Engineer

   Man hours work performed January 15, 1963 to April 25, 1963

4. John Gamblin - R & D Laboratory Technician

   Man hours work performed January 15, 1963 to April 25, 1963

5. William Waslaske - R & D Laboratory Technician

   Man hours work performed January 15, 1963 to April 25, 1963

(B) References

None

(C) Formulae

Calculated impedance and size formulae used in cables.

1. Capacitance $= \dfrac{(K)\ (7.36)}{\log_{10} D/d}$

2. Impedance $= Z_o = \dfrac{10600}{(\text{Capacitance})\ (\text{Velocity}}$
   MMF/Ft. %

3. Attenuation $= \dfrac{1}{1.46}\ 20 \log_{10} \dfrac{M1}{M2}$

4. Outer conductor braid angle and percent coverage.

   Percent coverage $= (2F-F^2)\ 100$

   Where: $F = \dfrac{NPD}{\sin \underline{/A}}$; $\tan \underline{/A} = \dfrac{2\pi\ (D + 2d)\ P}{C}$

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Formulae derived from MIL-C-17 latest issue.

Capacitance - Paragraph 4.6.7

Velocity - Paragraph 4.6.12.1

Impedance - Paragraph 4.6.12

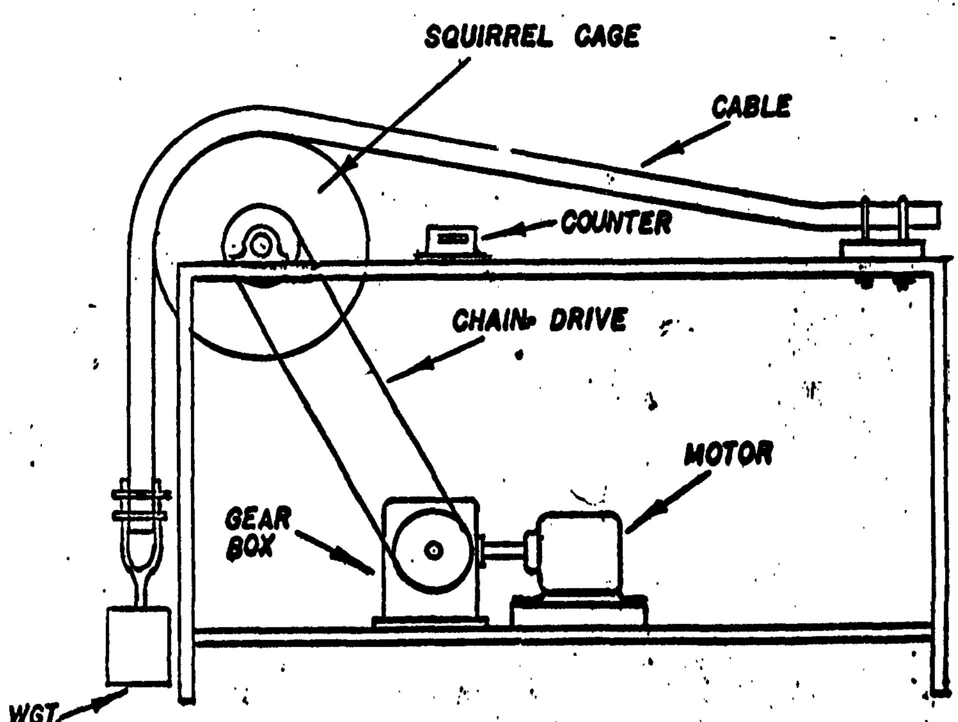
Attenuation - Paragraph 4.6.10

(D) Illustrations

None

(E) Measurement Procedures.

1. Attenuation - See report dated 28 January 1963.
2. Hydrostatic test set-up - See report dated 28 January 1963.
3. Non-restrictive gland assembly used for hydrostatic test. See report dated 28 January 1963.
4. Cold Bend test set-up - See report dated 28 January 1963
5. Abrasion Resistance test set-up per MIL-C-915 latest issue.



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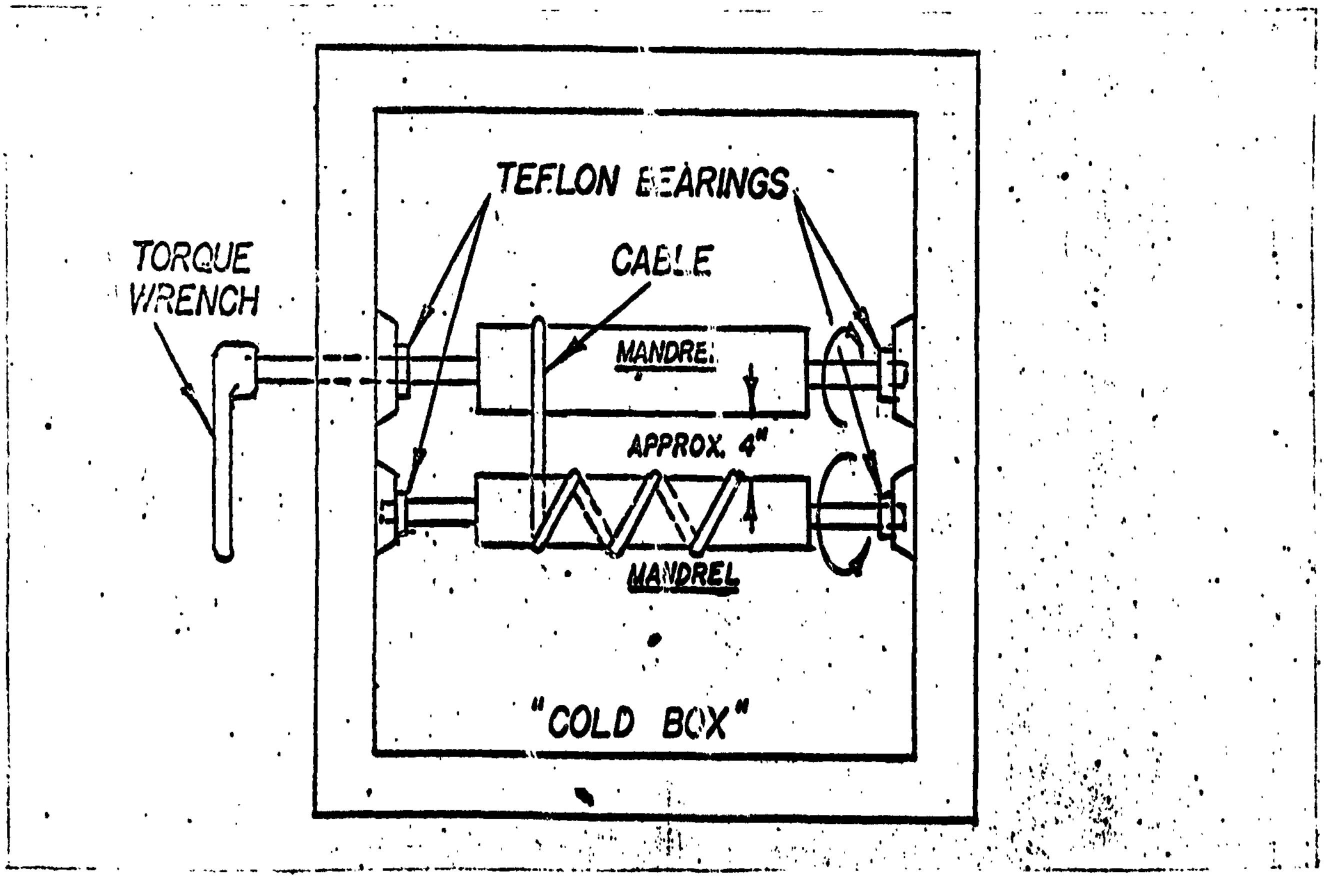
6. Pliability Test Set-Up.



7. <u>Instrument Tabulation</u>

a. Capacitance Bridge - General Radio Co. - Type 716-C

b. Oscilloscope Detector - A. B. DuMont Co. - Cathode Ray Type 304-A

c. Q-Meter - Boonton Radio Corp. - Type 170-A

d. Attenuation measuring devices

Signal Generator - Hewlett Packard Co. Model 608-C
Radar Receiver - R 54/Apr-4
Tuning Unit - TN-18/Apr-4 - Range 300 to 1000 MC
Tuning Unit TN 19 Apr/Apr-4 Range 975 to 2200 MC
Tuning Unit TN 54/Apr-4 - Range 2150 to 4000 MC

e. High Voltage Test Set - General Electric Co. - Type K

f. Hydrostatic Test Pump - Henderen Co. No. 30

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DETAIL FACTUAL DATA

As stated in the last report dated January 25, 1963, some difficulty was encountered in the blocking of silver plated copper strands in a stranded conductor. It was noted that after the cure cycle of the completed blocked stranding there would be no bond between the silver plated stranding and the RTV-60 silicone blocking compound. Several methods and materials were used in an effort to overcome this condition. At first it was thought that the priming agent was ineffective because of some chemical reaction to the silver plating. This was later disproved, the priming agent it was found would adhere very firmly to the silver plating but when the silicone compound was applied and cured the silicone and the priming agent would not bond. Different types of silicone compounds had no effect on this condition, the use of several types of priming agents had no effects and the results were still no bond. It seemed to us at this point that the answer must lie in the chemical reaction caused in the silver plating through the priming agent to the silicone blocking compound during the curing cycle. A series of tests were performed on the silver plated wire, several cleaning methods, wire drawing methods, plating methods etc. The problem was finally solved by the use of a special cleaning agent on the silver plated wire, the application of the normally used priming agent, the application of the RTV-60 silicone blocking compound with a special slow-acting catalyst, and the initiation of a special curing cycle. We now feel we can completely bond the blocking agent to the silver plated stranding. With this difficulty overcome a control sample of RG 217/U employing a blocked silver plated stranded conductor was fabricated using solid FEP as the primary dielectric material.

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Two samples of RG 217/U core were made. One with a solid silver plated copper conductor and one with a stranded silver plated copper conductor. Both samples are fabricated with solid FEP as a primary dielectric material. RG 218/U was made with only a solid silver plated copper conductor. It was felt that all test data concerning solid versus stranded conductors could be determined with only the one cable being made.

Next, the three cores were split up as follows:

RG 217/U - Solid conductor - the sample was shielded and blocked, a binder of mylar tape was applied over this shield and a second shield was applied over this and blocked with sealing compound. A double binder of adhesive mylar was applied over this shield. This core was then jacketed with a polyurethane jacket.

RG 217/U - Stranded Conductor - This sample was made up with the same construction as above except it was not jacketed. A glass braid was applied over the outer binder in place of the polyurethane jacket, this was done for attenuation readings only.

RG 218/U - Solid Conductor - A sample using the same construction as RG 217/U solid core was made. A sample was made eliminating the outer shield, thus making this a single shielded sample. Two types of jacket were used on this control sample. A polyurethane type jacket was applied to the double shielded first section, an arctic type, single neoprene jacket was applied to the single shielded second section. It was found during the hydrostatic tests performed on this single neoprene jacket, that at higher water pressures, in the vicinity of 2000 PSI or over, that if any water got under the jacket it would eventually work its way under

the stuffing tube grommet due to the flexibility of the neoprene and form a bubble on the part of the cable outside of the stuffing tube. If left for extended periods of time under pressure in excess of 2000 PSI this water filled bubble would eventually work its way down to the cable and leakage would occur under the jacket. It was decided that this might be overcome by the use of a reinforced neoprene jacket. The problem encountered at this time was what to use for reinforcement. From past experience it has been noted that any type of unsealed reinforcement such as cotton, rayon, glass threads etc. will cause a wicking action and leakage under pressure will occur at this point. Another problem was how to bond this reinforcement to the two layers of jacket. Many types of reinforcement were experimented with utilizing rubber bonding materials saturated right into the reinforcement threads. None of these proved successful, due to lack of bonding quality or lack of sealing quality causing the wicking action before mentioned. We finally derived at a solution containing a dispersion of neoprene compound that would thoroughly saturate the glass thread reinforcement which we preferred to use, as well as affording an excellent bond to the jacket layers. This worked quite well as will be noted in the test results of this report.

Some successful work has been done on the foam version of the RG 218 cable which is the larger of the three and we felt that the concentration should initially focus on this larger cable. A solid conductor with foamed FEP primary has been fabricated which has passed the hydrostatic pressure of 1000 PSI for 2 hours with "0" leakage. The cable core did tend to leak slightly after 1 hour at 1500 PSI. The extrusion is still slightly rough as far as outside O.D.'s are concerned, but this condition can be taken

care of in the extrusion technique. The core O.D. of this cable will be approximately .540. This is somewhat lower than the .585 O.D. required for the solid FEP extrusion and would result in a smaller overall O.D. This would also afford a great savings in weight as the solid FEP material is approximately 40% to 50% heavier than an equal amount of foamed FEP.

Electrical readings on the foamed control sample core are as follows:

Capacitance - 25.63 MMF/Ft.

Velocity - 79.8%

Impedance - 49.7 Ohms

A pliability test was performed on this core with the following results:

	Results
Cable - RG 218/U Foamed FEP Core Solid Conductor	
Construction - FEP Foamed Primary	156 inch/lbs.

Taking the various cables step by step through the different tests applicable in specification MIL-C-4017 the following results were noted.

Attenuation Aging Stability and Contamination

Cable - RG 217/U
Solid Conductor

Construction - Double Shield
Estane jacket

	Frequency	Attenuation
Original sample before aging	400 M.C.	4.87 db/100'
	1000 M.C.	10.96 db/100'
	3000 M.C.	18.62 db/100'
After aging for 7 days at 98°C and 12 hours at room temperature	400 M.C.	4.73 db/100'
	1000 M.C.	9.80 db/100'
	3000 M.C.	17.31 db/100'
After cold bend test 20 hours at -55°C Specimen wound on a 10 X mandrel	400 M.C.	4.78 db/100'
	1000 M.C.	9.96 db/100'
	3000 M.D.	17.42 db/100'

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Cable - RG 217/U

Note: Readings taken on primary core with stranded conductor - Double Shielded

No shield blocking - A braided jacket overall.

	Frequency	Attenuation
	400 M.C.	8.26 db/100'
	1000 M.C.	14.81 db/100'
	3000 M.C.	25.90 db/100'

Cable - RG 218/U
Solid Conductor
Construction - Double Shield
Estane Jacket

Original sample before aging	400 M.C.	2.92 db/100'
	1000 M.C.	6.07 db/100'
	3000 M.C.	13.49 db/100'
After aging for 7 days at 98°C and 12 hours at room temp.	400 M.C.	2.87 db/100'
	1000 M.C.	6.00 db/100'
	3000 M.C.	13.12 db/100'
After Cold Bend test 20 hours at -55°C Specimen wound on a 10 X mandrel	400 M.C.	2.96 db/100'
	1000 M.C.	6.23 db/100'
	3000 M.C.	13.71 db/100'

Cable - RG 218/U

Construction - Same as above except single shield

Original sample	400 M.C.	2.92 db/100'
	1000 M.C.	6.23 db/100'
	3000 M.C.	13.41 db/100'

Note: 1. It is noted that if connectors and cables at terminations are not cleaned thoroughly of all excess blocking compound the attenuation readings will be noticeably higher.

2. Per the above readings it is noted that the attenuation of a single shielded construction is equal to that of a double shielded construction. These cables will be constructed with single shielding, 90% minimum coverage, flat angle braid in order to yield better flexibility, lower cost, less weight, and smaller size.

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Cold Working

Cable / Construction	Results
Cable - RG 217/U **Construction** Solid Conductor Double Shield Polyurethane jacket	Failure Reason: Polyurethane jacket shattered. Six tests were made on this construction and in each case the jacket shattered before a full turn was made on the mandrel.
Cable - RG 217/U **Construction** Stranded blocked conductor FEP Extrusion	No cracks or derangement noted after full test on core. Core passed 2000 PSI hydrostatic test immediately afterward with "0" leakage.
Cable - RG 218/U **Construction** Solid Conductor Double Shield Polyurethane Jacket	Failure Reason: Same as noted on RG 217/U
Cable - RG 218/U **Construction** Solid Conductor Double Shield Single Neoprene Jacket	Cable passed "S" bend with no cracks or derangement noted. Specimen passed 1000 PSI hydrostatic pressure for 2 hours with "0" leakage. As pressure was increased to 2000 PSI it was noted that a water bubble was forming on the outside end of the cable immediately outside the grommet. This condition was explained in an earlier part of this report.
Cable RG 218/U **Construction** Solid Conductor Single Shield Single Neoprene Jacket	Same as for above cable.
Cable RG 218/U **Construction** Solid Conductor Single Shield Reinforced Neoprene Jacket	Same as above except it was noted that water bubble did not form on outside end of cable.

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Note: It is worth noting on this cold bend test that the polyurethane jacketing material would invariably pass on a straight mandrel cold bend test per MIL-C-17 but would invariably fail when an "S" bend was imposed. This we believe is due to the opposite force stress put on the material.

It is also worth noting that estane material tends to decompose after approximately 10 weeks in water at room temperature. This decomposition will accelerate with an increase in water temperature and decelerate with a decrease in water temperature. Estane is notably a water sensitive material and for this reason we do not recommend it for a cable with these requirements. Some improvement in this material has been made in very recent times, the amount of improvement and test results will take many weeks to evaluate. We feel therefore that with your requirement for a polyurethane bondable material that noeprene is the superior material.

Pliability

Tests performed at -50°C
Calculated Torque on equipment only at -50°C - 12 inch/lbs.

Cable RG 217/U		**Results**	
Construction	Solid Conductor Solid FEP	Primary cores only for evaluation between solid and stranded conductors	216 inch/lbs.
Cable RG 217/U			
Construction	Stranded blocked conductor Solid FEP		216 inch/lbs.

Note: Per the results of the test it seems to make no difference between solid and stranded conductors as for pliability is concerned. The reason for this we believe is that the primary insulation is stiff enough at low temperature to overcome any pliability advantage gained in the stranded conductor.

Cable - RG 217/U

Construction Solid Conductor
Double Shield
Polyurethane Jacket — 276 inch/lbs.

Cable - RG 218/U

Construction Solid Conductor
Double Shield
Polyurethane Jacket — 550 inch/lbs.

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Cable	RC 218/U	**Results**
Construction	Solid Conductor Double Shield Single Neoprene Jacket	502 inch/lbs.
Cable	- RG 218/U Solid conductor	502 inch/lbs.
Construction	Double Shield Reinforced Neoprene Jacket	
Cable	- RC 218/U	
Construction	Solid Conductor Double Shield Estane Jacket	550 inch/lbs.
Cable	- RG 218/U	
Construction	Solid Conductor Single Shield Reinforced Neoprene Jacket	492 inch/lbs.

Watertightness

All cable constructions passed the 1000 PSI for 2 hours with "0" leakage.

All cable constructions passed at 2000 PSI for 2 hours with "0" leakage except for the noted difference in performance between the single neoprene and reinforced neoprene constructions.

Aging Stability

Cables passed as noted in the Attenuation Section of this report.

Abrasion Resistance

Test set up as called out in specification MIL-C-915.

Cable	- RG 217/U	**Results**
Construction	Estane Jacketed	1000 cycles - passed 1788 cycles - cut-through
Cable	- RG 218/U	
Construction	- Estane Jacketed	1000 cycles - passed 2463 cycles - cut-through

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<u>Cable</u> -	RG 218/U	<u>Results</u>
<u>Construction</u>	Single Neoprene Jacket	1000 cycles - passed 4960 cycles - cut-through
<u>Cable</u>	RG 218/U	
<u>Construction</u>	Reinforced Neoprene Jacket	1000 cycles - passed 6647 cycles - cut-through

<u>Contamination</u>

Test results as noted in Attenuation Section of this report.

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Project Performance and Schedule Chart

Project Serial No. SR008-80-302 Task No. 9634

Contract No. NObsr-87574 Report Date April

Period Covered January 15, 1963 to April 25, 1963

Legend:

= Work performed

= Schedule of projected operations

P.D. = Preliminary Design
T.R. = Test Run
T. = Test
R.O. = Run Order
S.O. = Submit Order

Item: Estimated completion in percent of total effort to be expended. (Not chronological)

	RG 11 A/U	RG 217/U	RG 218/U
1. Conductor	100%	85%	85%
2. Primary Dielectric	85%	85%	85%
3. Shielding	95%	95%	95%
4. Jacketing	95%	95%	95%
5. Testing	90%	90%	90%
6. Run 2000' order	0%	0%	0%

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PROJECT PERFORMANCE AND SCHEDULE CHART
Project Serial No. SR008-80-302 Task - 9634
Contract No. NObsr 87474 Report Date April 25, 1963

Period Covered 1/15/63 to 4/25/63

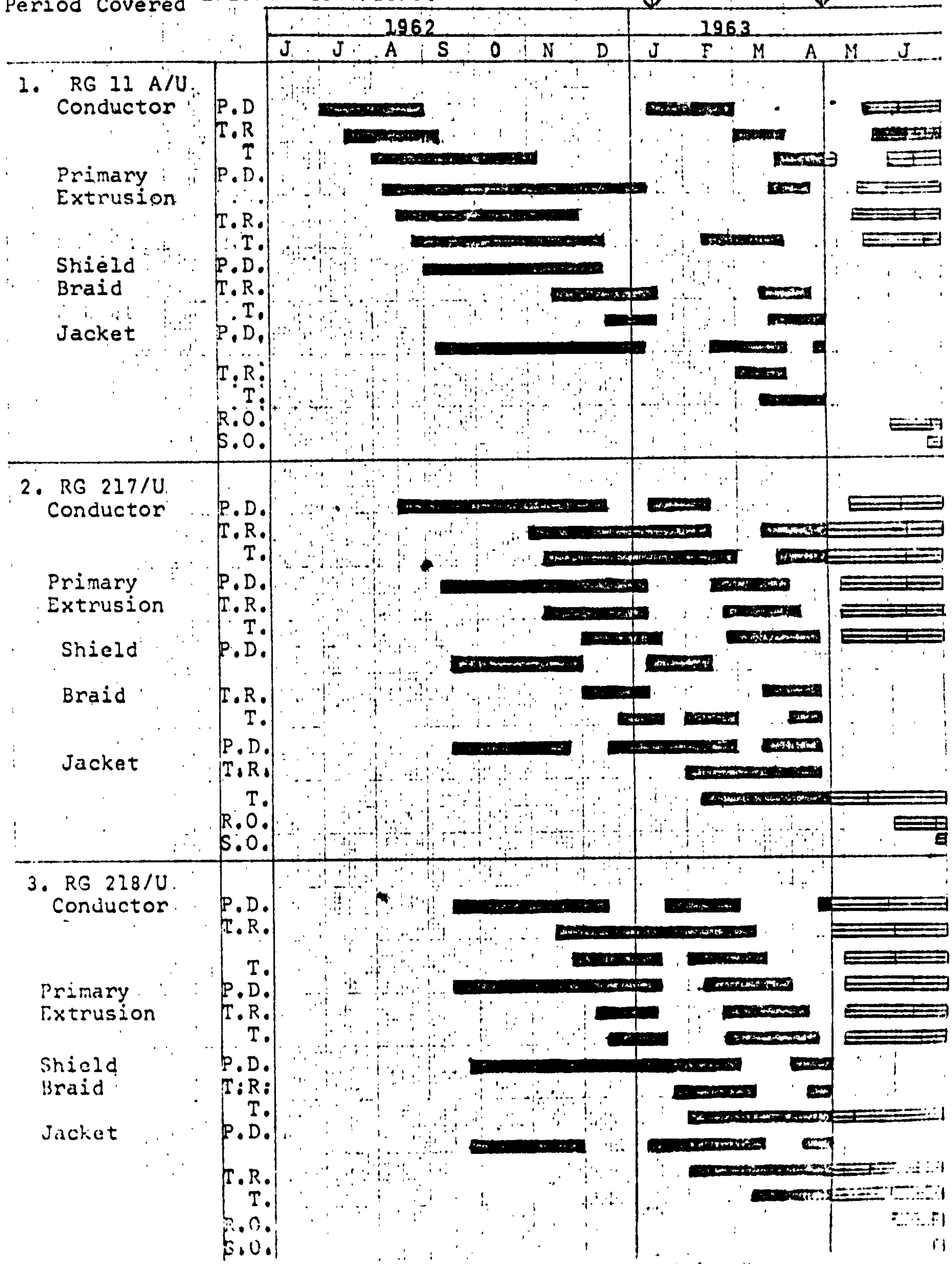

Figure [illegible] Project Performance and Schedule Chart

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CONCLUSION

Data revealed in the various tests performed on these cables. The following conclusions have been reached:

1. We are now capable of furnishing cables to meet the main objectives of specification MIL-C-4017. These main objectives are as follows:

   (a) Attenuation - Very low losses have been achieved with the cables as now fabricated.

   (b) Flexibility - The standards set up in the pertinent specification have been met, but this is one area where an improvement could be attained.

   (c) Hydrostatic - All cables have gone to 1000 PSI with 0 leakage over the specified time.

   (d) Mechanical Ability - All cables have passed this 1000 cycles abrasion as set up in MIL-C-915 with a great deal of margin.

   (e) All cables have met the capacitance and impedance requirements.

2. All cables have made use of dielectric and jacket materials which will not support combustion. This is in contrast to polyethylene dielectrics which can readily propagate flame from one compartment to another in case of a serious fire. This material has also undergone a long time soak test with excellent results. Cables jacketed with Surco arctic neoprene has been immersed in salt water for several weeks and successfully passed the cold bend test @ 55°C immediately afterward. It was also noted that no water penetrated through to the cable core during this test. Extended tests of several months indicate no appreciable water transmission or absorbtion as indicated by maintenance of insulation resistance of sheath above 1000 megohms per 1000 feet. These features we feel are very important to this cable and may be achieved with properly compounded artic neoprene.

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3. The use of FEP as a dielectric material affords a high melting point material which gives excellent solderability, and permits higher molding temperatures at terminations than polyethylene.

4. The use of a foamed FEP material as a primary dielectric would be very desirable because of the lowered O.D.'s, the great weight savings, and the increase flexibility. The effect of compressibility and electrical change under hydrostatic pressures of 1000 PSI to 2000 PSI and up have yet to be determined. Flexibility of a foamed FEP dielectric is considerably better at lowered temperatures.

5. The use of a single shielded construction is preferable to a double shielded construction. A single shield affords no more electrical loss than a double shielded construction. It also enables us to lower the overall O.D., weight, and cost and flexibility.

6. With solid dielectric a stranded sealed conductor does not afford noticeable more pliability in the overall cable than a solid conductor, especially at lowered temperatures. A solid conductor would be somewhat easier for application of connectors, because of the lack of sealing compound to clean away. A stranded conductor also has a tendency to raise the electrical losses especially at the higher frequencies. We believe this to be dielectric losses in the sealer.

7. The use of a polyurethane jacketing material is not desirable because of the so called "water-sensitivity" of the material. After prolonged soaking in water at 70°F temperature the material tends to decompose, become soft and putty-like. The use of neoprene as a jacketing material while not being quite so good hydrostatically because of the rubbery nature of the material, has much better flexibility at lower temperatures, is bondable to polyurethane, and has good abrasion resistance.

Neoprene, then would be the recommended material for this cable.

8. As reported in our January 25, 1963, report we had no success in applying foam FEP dielectric stranded conductor and maintaining watertightness. We have however a new concept on blocking techniques which should permit the application of foam while maintaining watertight integrity. This blocking system uses only materials known to be good dielectric so the attenuation should not suffer as it did in case of stranded conductor under foam FEP.

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PROGRAM FOR NEXT INTERVAL

What we hope to accomplish in the next period is outlined as follows:

1. Construct prototype RG 217/U using new technique with stranded conductor and foam dielectric to achieve the ultimate in size, weight, flexibility, and electrical properties and low temperature properties.

2. Complete and test RG 218/U with foam dielectric and solid conductor.

3. After consultation with the Bureau of Ships choose the cable most desirable to the Bureau and produce the required 1000 foot quantities of RG 11 A/U, RG 217/U, and RG 218/U.

4. Complete qualifying tests and write final report.